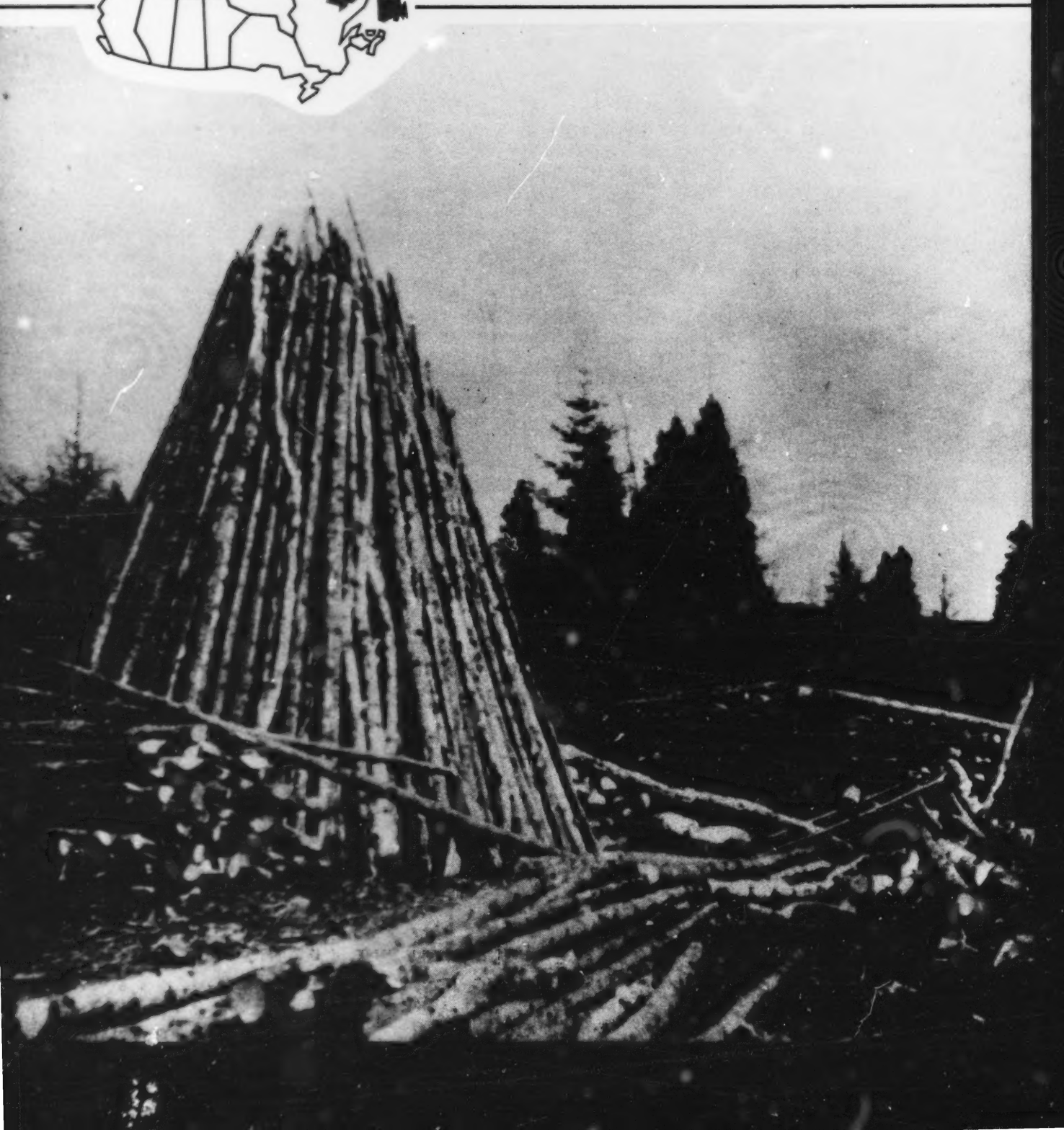
Government of Canada
Gouvernement du Canada

Canadian Forestry Service
Service canadien des forêts

Afforestation of Heathlands in Eastern Newfoundland

J. Peter Hall

Information Report N-X-253
Newfoundland Forestry Centre



87-03775/

NEWFOUNDLAND FORESTRY CENTRE

The Newfoundland Forestry Centre (NeFC) is an establishment of the Canadian Forestry Service. The Centre conducts most of the forestry research in the Newfoundland Region and is one of six similar regional establishments in Canada.

The objective of NeFC is to provide the scientific, technological and economic information and services required for the improvement, protection, and efficient utilization of the forest resources of the province of Newfoundland and Labrador. Its work is directed towards satisfying the requirements of the Provincial Government, the forest industry, federal agencies having forestry related programs and other clients of the Canadian Forestry Service; many of its studies are undertaken jointly with client agencies. The Centre attempts to bring the results of research to potential users by publishing information reports, articles in scientific journals, and by demonstrations of research results. It seeks to keep the public informed of its work by means of special displays, seminars, and related activities.

The NeFC program has three principal components - Forest Resources and Environmental Research, Forest Protection Research, and Forestry Development.

AFFORESTATION OF HEATHLANDS IN EASTERN NEWFOUNDLAND

by J. Peter Hall

INFORMATION REPORT N-X-253
1986

CANADIAN FORESTRY SERVICE
NEWFOUNDLAND FORESTRY CENTRE

©Minister of Supply and Services Canada 1986

ISSN NO. 0704-7657
CAT. NO. Fo46-15/253E
ISBN NO. 0-662-15127-5

Copies of this report are available at no charge from:

Newfoundland Forestry Centre
Canadian Forestry Service
P.O. Box 6028
St. John's, Newfoundland
Canada A1C 5X8

Telephone No. 709-772-4117

ABSTRACT

The attempts at afforestation of the heathlands of eastern Newfoundland from 1937 to 1970 are described. It is concluded that commercial forests can be established on sheltered sites modified by ploughing, and planting large vigorous seedlings at close spacing. Recommended species include Japanese, European and eastern larch, Scots and jack pine and Sitka spruce. The expected end product will likely be firewood, a product in considerable demand in the area.

RÉSUMÉ

Sont décrits les efforts decréation de forêts sur les landes de l'est de Terre-Neuve entre 1937 et 1970. Il en ressort que des forêts commerciales peuvent être établies sur des terrains abrités, modifiés par labourage avant la plantation de gros semis vigoureux à faible espacement. Les espèces recommandées comprennent le mélèze du Japon, le mélèze d'Europe et le mélèze laricin, le pin sylvestre et le pin gris, ainsi que l'épinette de Sitka. Le bois de chauffage, pour lequel il existe une demande considérable dans la région, serait probablement le produit final.

TABLE OF CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	i
LIST OF TABLES	iii
ACKNOWLEDGEMENTS	iv
INTRODUCTION	1
DESCRIPTION OF THE AREAS	2
Establishment of Plantations	4
Species Planted	4
Planting Methods	6
Plantation Assessments	6
RESULTS AND DISCUSSION	7
Plantations Established Between 1937 and 1951	7
Plantations Established Between 1966 and 1970	12
CONCLUSIONS	19
LITERATURE CITED	22
APPENDIX I	25

LIST OF TABLES

		Page
1.	Species planted in afforestation trials.....	5
2.	Proportion of four plantations rated as successful, partly successful and unsuccessful	8
3.	Height growth of species planted in three plantations	8
4.	Area of sites and list of species planted on the Avalon Peninsula 1966-70	13
5.	Percentage survival over two periods in four plantations on ploughed heathlands	14
6.	Average total height of planted trees over two periods in four plantations	16
7.	Species planted, survival and growth at Avondale 20 years from seed.....	18

ACKNOWLEDGEMENTS

The author is indebted to many people and specifically to those who made the initial assessments of the plantations almost 35 years ago; those who established the novel experiments based on the early results and finally those who provided remeasurement data on the newly established plantations. These people include: H.S. Lewis, D.E. Nickerson, W.C. Wilton, C.H. Evans, E.C. Salter, J. Richardson, A.B. Case, P. Tricco and W.J. Curran.

I would like to thank E.D. Wells, W.J. Meades, R.S. van Nostrand and A.B. Case who suggested many improvements in the manuscript.

AFFORESTATION OF HEATHLANDS IN EASTERN NEWFOUNDLAND

by

J. Peter Hall

INTRODUCTION

The barren heathlands of eastern Newfoundland are perhaps the most distinctive feature of the landscape. Vegetation on these barrens consists largely of ericaceous dwarf shrubs and scrubby conifers growing on thin podzols. Most of these heathlands were created by and are maintained by fire, and Meades (1983) considers the "landscape as permanent under prevailing climatic conditions" (p. 305).

The similarities of the Newfoundland heathlands to those of Scotland and Scandinavia have stimulated many proposals during the last fifty years for the afforestation of these areas. Serious attempts at afforestation were begun about 1937 and these continued sporadically until about 1950. Many of the plantings were unsuccessful and in the 1960s various experiments were conducted to see if site modifications and substitution of other tree species were useful in increasing success rates. To date there has been no comprehensive assessment of the various plantation trials conducted on various sites. This paper integrates the data which have been collected and makes recommendations on the potential for afforestation of these heathlands.

DESCRIPTION OF THE AREAS

The areas studied are on the Avalon and Bonavista peninsulas of eastern Newfoundland and lie between 46°-49°N latitude and 52°-54°W longitude. The topography is a rolling plateau underlain by a variety of sedimentary and volcanic rocks (Rowe 1972). Lakes and ponds are abundant (8% of total area) and the area is drained by many small rivers. Soils are thin and composed primarily of nutrient poor humo-ferric and ferro-humic podzols. The climate is very strongly influenced by the proximity to the sea, precipitation is abundant (870-1400 mm) and well distributed throughout the year. Mean temperature in July is 16°C and -5°C in February. Fog is common throughout the year especially in the spring (Wilton 1956; Wilton and Lewis 1956).

Slightly more than one-third of the land mass of the two peninsulas is forested; these forests are dominated by balsam fir (Abies balsamea (L.) Mill.) with lesser amounts of white spruce (Picea glauca (Moench.) Voss), black spruce (P. mariana (Mill.) B.S.P.) and tamarack (Larix laricina (Du Roi) K. Koch.). Hardwoods occur sporadically in the deeper and more sheltered valleys and consist of white birch (Betula papyrifera Marsh.) and rarely yellow birch (B. alleghaniensis Britton) (Rowe 1972). These forests have been exploited since the area was first settled in the seventeenth century and until recently cutting was unrestricted in quality or quantity. Thus there has been a reduction in area and quality in most of the coastal forests (Nickerson 1951). Harvesting of firewood now occurs in stands of fir which are not yet of seed bearing

age and once cut these stands do not reproduce. This also reduces the area of forested land.

The most destructive agent of these forests is wildfire. A history of wildfire in eastern Newfoundland has listed a total of 566 fires each covering 0.4 ha or more between 1619 and 1960 (Wilton and Evans 1974). The largest fire recorded burned 2 000 ha. Fire in fir forests destroys both seed source and advance growth of fir and burned sites remain unstocked to fir. They become stocked to birch or black spruce but most of the areas will remain unforested. Repeated burning ensures the development and maintenance of barren heathlands which are stable and unlikely to revert to forest (Meades 1983). These heathlands are extensive, occupying an estimated 720 000 ha on the Avalon and Bonavista peninsulas (Anon. 1974).

Heathlands are common in boreal climates; and in Scotland and Scandanavia heathlands have been afforested and support productive forests. The impetus for this afforestation was a shortage of wood in these countries. In the coastal areas of Newfoundland wood is in high demand for construction, boat building and increasingly for firewood. Over one-third of the Province's sawmills are located on the Bonavista and Avalon peninsulas and represent an important source of employment and income (Mallay and Milne 1981; Milne 1984). There is, however, a chronic shortage of sawlogs. Current utilization of forests for fuelwood exceeds the annual allowable cut for eastern Newfoundland (Anon. 1984). An increase in the area of productive forest would be of considerable value to the local economy. The combination of demand for wood and examples of

successful afforestation elsewhere led to the attempted afforestation of the heathlands in eastern Newfoundland.

This afforestation program is described in two parts: plantings from 1937 to 1951; and 1966 to 1970. The methods used and species tested are described separately.

ESTABLISHMENT OF PLANTATIONS

Species Planted

A wide variety of species had been planted at various times (Table 1). Before 1942 plantings used mostly balsam fir and white spruce (Lewis 1954). As a result of failures using these species emphasis then switched to jack pine, Scots pine and Norway spruce. By 1944 Norway spruce was the most commonly planted species. In the late 1940s pines became the predominant species. Various hardwoods (Table 1) were planted in 1946 and 1947 but none were successful and were not used in any later plantings. A test of exotics by the Canadian Forestry Service had shown some promise for Sitka spruce and this species was widely used in the second series of plantings (1966-70) (Nickerson et al. 1964). Later plantings also used native black and white spruce and both native and exotic larches.

Seedlings for all trials were grown in Newfoundland. The seed used in the first series (1937-51) was purchased from commercial seed dealers and little or no information is available as to seed source. Most seed sources of the second series of plantings are known (Appendix I). A variety of species was planted in the different plantations and not all are replicated in each site.

Table 1. Species planted in afforestation trials.

Scientific name	Common name
Pinus resinosa Ait.	Red pine
P. strobus L.	White pine
P. banksiana Lamb.	Jack pine
P. contorta Dougl.	Lodgepole pine
P. ponderosa Laws.	Ponderosa pine
P. sylvestris L.	Scots pine
P. nigra Arn. *v. austriaca* (Huess) Aschers	Austrian Pine
P. nigra Arn. *v. corsicana* Loud.	Corsican pine
Picea mariana (Mill.) B.S.P.	Black spruce
P. glauca (Moench.) Voss	White spruce
P. rubens Sarg.	Red spruce
P. sitchensis (Bong.) Carr.	Sitka spruce
P. englemannii Parry	Englemann spruce
P. abies L.	Norway spruce
P. jezoensis (S. & Z.) Carr.	Hondo spruce
Larix laricina (Du Roi) K. Koch	Tamarack (eastern larch)
L. decidua Mill.	European larch
L. kaempferi (Lam.) Carr.	Japanese larch
Abies balsamea (L.) Mill.	Balsam fir
Betula papyrifera Marsh.	White birch
B. japonica Winkl.	Japanese white birch
Quercus rubra L.	Red oak
Ulmus americana L.	American Elm
Acer saccharinum L.	Silver maple
Fraxinus L. spp.	Ash

Except for a few experimental seeding trials (all unsuccessful) attempts at afforestation involved hand planting of bareroot stock. Planting stock was primarily 2 + 2 for spruces, i.e., two years in seedbeds and a further two in transplant beds. Planting with pines often used 2 + 1 or 2 + 0 stock (Lewis 1954). Most of the earlier plantations were fenced to prevent grazing damage by sheep and goats. This was not necessary for the plantations established after 1966 because by then it was uncommon for animals to be roaming freely.

Planting Methods

For the later plantings (1966-70) the sites were ploughed in order to improve the microsite for planting and early growth (Wilton 1970). A Parkgate Tine Plough was used, pulled by a D-4 caterpillar tractor. The furrows were spaced at 1.8 m. The production rate varied widely from 5 to 12.5 hours per hectare. This variability was affected by ground conditions and operator experience. Trees were planted on the side of the furrow which afforded some shelter. In some plantations the trees were fertilized with approximately 60 g of ground mineral phosphate applied around the base of each tree.

Spacing in the earlier plantations (1937-51) varied from 1.5 to 2.1 m (Lewis 1954). In the later series of plantations spacing was 1.8 m. Because of the rocky nature of the terrain actual spacing was probably more variable.

Plantation Assessments

The plantations were assessed for survival and height growth at different stages during their development. Survival counts were commonly

done within one or two years and causes of mortality determined. Since then there have been sporadic measurements of height. In 1985-86 remeasurements were made in four plantations on the Avalon Peninsula when the planted trees were 20 years from seed.

RESULTS AND DISCUSSION

Plantations Established Between 1937 and 1951

Twelve plantations comprising an estimated 800 ha were established by the Newfoundland Government (Lewis 1954). In Lewis' (1954) report "Forest Plantations in Newfoundland", height measurement and tree form were recorded and in some cases causes of mortality were described. (Several parts of plantations had been replanted 1-2 years after establishment.) Each plantation or parts thereof was described as:

Successful - fully stocked stand will probably develop

Partly successful - understocked stand may eventually develop

Unsuccessful - no stand will develop.

Only a portion of one plantation was considered successful (Table 2). Growth of trees was slow (Table 3), and only three of the twelve plantations had enough trees in the successful or partly successful category to enable height measurements to be taken (Table 2). Measurements in the Colliers plantations were taken when the trees were 38 years old. The trees, however, were too crooked and poorly formed to be useful for anything other than firewood. An examination of the plantation in 1986 showed that:

(i) Trees were being , and for several years had been, cut for firewood.

Table 2. Proportion of four plantations rated as successful, partly successful and unsuccessful.

Plantation	Total Area (ha)	Area (ha)		
		Successful	Partly Successful	Unsuccessful
Colliers	24.3	12.2	8.1	4.0
Brigus	26.7	0	0	26.7
Bonavista	22.4	0.4	4.1	17.9
Catalina	32.3	0	16.1	16.2
Total	105.7	12.6	28.3	64.8

Table 3. Height growth of species planted in three plantations.

Species	Total Height (m) in Each Plantation					
	Colliers	Colliers	Bonavista		Catalina	
Seedling age*	**12**	**38**	**9**	**11**	**9**	**11**
Jack pine	1.27	5.87	.79		.48	
Scots pine	1.35	8.46**	.56		.38	
White pine	-	-		.25		.25
Red pine	-	-		-		.28
Norway spruce	-	-		.61		.38

*Age from seed - planting stock assumed to be 2 + 2.

**This species planted on a sheltered forested site on the Avalon Peninsula averaged 12.0 m at age 45.

(ii) A second generation of pines and spruces is becoming established naturally.

(iii) Stem form in the new stand is superior to that in the original stand.

The description given by Lewis (1954)(p. 6) for the Brigus plantation describes the fate of the unsuccessful plantations. He states:

> "This plantation of approximately 66 acres is located on a hill barren near the town of Brigus. The area is completely devoid of natural forest growth and is covered with Kalmia and blueberry bushes. The plantation has been enclosed with stock fencing.
>
> In 1942, a part of the area was planted with local balsam fir and white spruce. In the ensuing eight years nearly all these trees died and the majority of the few alive are badly stunted. The next planting was made in 1947 when a small number of Scots pine, silver maple, white spruce, American elm, and white birch were set out. The examination revealed that none of the hardwoods and few of the pine and spruce were still living. Again it was found that the surviving trees were in small sheltered pockets, but were too scattered for measurement. A further planting was made in 1948 with 25,000 Scots pine and 20,000 jack pine. Only a few of these trees can be found scattered over the area. The final planting was made in 1951 with 31,000 Scots pine of which few are expected to survive.
>
> An examination of the soil at various places on the plantation indicated the usual red sandy loam, but very compact and rocky. Further planting on this location appears useless, at least for those species already tried."

The conclusions reached by Lewis (1954) are interesting and concisely sum up the efforts made by the early afforestation attempts (pp. 13-14).

"It is concluded that:

1. Exposure rather than soil conditions plays the major role in plantation failure;

2. Fencing of plantations to prevent browsing by livestock is a necessity except in remote areas;

3. Plantations of hardwood species have been complete failures;

4. The successful afforestation of large expanses of open barren land such as are found on the Avalon and Burin peninsulas and elsewhere in Newfoundland cannot be accomplished by ordinary planting methods with any species tried to date. Instead, highly specialized techniques are required, and much research would be required to determine which of these methods would be most applicable to Newfoundland conditions;

5. The afforestation of sheltered slopes and hollows in otherwise sheltered windswept barren country is possible by planting Scots pine and jack pine;

6. Red pine and Norway spruce are suitable for planting in southeastern Newfoundland in openings in existing stands or in otherwise well sheltered locations."

In light of subsequent developments these conclusions seem quite prescient.

Based on the results of these early afforestation attempts, an experiment was established in 1952 by the Canadian Forestry Service[1] to test the effects of exposure on tree growth. A variety of exotic species was planted at four exposed sites on the Avalon Peninsula (Nickerson et al. 1964). At each site planting was done in a microsite of maximum, minimum and average exposure. Survival and growth were best where exposure was least. A combination of suitable species and seed source and good microsite for planting showed that successful establishment and tree growth was possible. Both Scots pine and Sitka spruce survived and

[1]Then Forest Research Division, Dept. Nor. Aff. and Nat. Res.

grew well. This is the first use of Sitka spruce in afforestation of heathlands. The experiment showed "that there is a marked affinity between success of the common shrub, mountain alder[2] and the success of Sitka spruce" (Nickerson et al. 1964).

These heathland planting trials illustrate many of the limitations in afforesting heathlands and have shown where to plant and to some extent, what to plant. The following conclusions can therefore be drawn from these studies:

1. Exposure is the major cause of plantation failure. Exposure can be avoided by selecting sheltered topography for planting. Exposure can be further modified by the mutual shelter provided within plantations.
2. Protection against grazing damage, once essential, is now unnecessary because livestock are fenced.
3. A variety of species proved successful under the adverse exposure conditions - jack pine, Scots pine, Sitka spruce and to a lesser extent red pine and Norway spruce.
4. A fortuitous combination of site (moist, sheltered), ground cover (mountain alder) and reforestation species (Sitka spruce) proved to be quite successful. This opened up the way for further refinements of this combination which should be applicable in many parts of the Avalon Peninsula.

---

[2] Alnus crispa (Ait.) Pursh.

5. The nearly uniform failure of plantations on the Bonavista Peninsula resulted in the abandonment of attempts at afforestation there. The heaths of the area, dominated by Empetrum nigrum and/or E. eamseii were largely exposed headlands and as a result had a much more severe climate than the Kalmia heaths of the Avalon Peninsula (Meades 1983).

Plantations Established between 1966 and 1970

The second series of heathland plantations, established between 1966 and 1970, were all on sites treated by ploughing (Evans and Salter 1969). This site treatment followed an earlier recommendation for specialized techniques to establish trees. Ploughing broke up the organic layer which ranged in depth from 10 to 50 cm. Trees were planted in one or more combinations of mineral soil and/or organic matter. Sites were quite rocky and had varying degrees of exposure. Four areas on the Avalon Peninsula were ploughed and subsequently planted to a variety of species (Table 4).

Seedlings in all plantations except Avondale were frost-heaved as a result of a mild winter (with little or no snow cover) in 1967-68. In May-June, 1968 seedlings were replanted. Richardson (1968) studied the frost-heaving problem in the Come-by-Chance plantation where it was most widespread and concluded that the problem might be alleviated by several approaches including the use of larger planting stock (i.e. 2 + 2 or older) or deeper planting. The problem might also be avoided by using shelterbelts or by delaying planting until a cover of natural

Table 4. Area of sites and list of species planted on the Avalon Peninsula 1966-70.

Species	Seedlot No.	Area Planted (ha)				
		Avondale	Come-by Chance	Chapel Arm	Mobile	Total
Red pine	14	-	-	.05	-	.05
Jack pine	23	.27	-	.45	-	.72
Scots pine	55	.61	1.66	.56	-	2.83
Black spruce*		.36	7.89	1.67	4.03	13.95
White spruce	24	.32	-	-	-	.32
Red spruce	26	-	-	.35	-	.35
Englemann spruce	35	.32	-	-	-	.32
Norway spruce	50	-	-	-	1.07	1.07
Sitka spruce	29	.18	.40	3.63	3.26	7.47
Eastern larch	27	.50	.45	.08	-	1.03
White birch	138	-	-	.30	-	.30
Total planted		2.56	10.40	7.09	8.36	28.41
Total ploughed		5.83	10.49	9.35	11.01	36.68

*Black spruce seed originated in central Newfoundland, all other seed sources were from mainland Canada or Europe (see Appendix I).

vegetation including grasses is established. This was observed at Avondale where the natural vegetation prevented frost upheaval during the same period.

The plantations were next remeasured in 1972, six years after establishment (Case 1977). Survival was again measured when the trees were 20 years old from seed (17 years from planting). Most mortality took place during the first few years of establishment and has not increased by much since (Table 5). Best survival was at Avondale where as noted there was considerable ground vegetation which afforded protection. Lowest survival was at Chapel Arm, considered to be the most exposed of the four (Case 1977).

Table 5. Percentage survival over two periods in four plantations on ploughed heathlands.

	Percentage Survival*, Each Plantation, Each Measurement							
Species/	Avondale		Come-by-Chance		Chapel Arm		Mobile	
Seedling Age	15	20	8	20	8	20	8	20
Jack pine	90	90	-	-	0	0	-	-
Scots pine	53	50	60	56	41	40	-	-
Black spruce	46	42	54	40	63	30	70	40
White spruce	31	28	-	-	-	-	-	-
Norway spruce	-	-	-	-	-	-	78	60
Sitka spruce	21	16	56	38	21	15	76	60
Eastern larch	81	78	72	70	37	32	-	-

*Survival is estimated; based on number of line trees in a plot of 0.04 ha.

Among the various species jack pine and eastern larch had excellent survival at Avondale but not at all plantations. Black spruce had the best overall survival. The data indicate that, except in the most exposed locations, it is possible to establish trees on barren heathland sites. The more sheltered sites at Mobile and Avondale had the best survival. At Mobile which had much of its shelter provided by alder, survival of two exotic spruces, Sitka and Norway were superior to that of black spruce. Data from a provenance trial of Sitka spruce which included local black and white spruce also showed the exotics to have superior survival.[3]

Height growth has been greatest at Avondale where better site conditions have permitted development of what is now a closed stand (Table 6). Tree crowns were deformed by the wind but in most cases a reasonably straight stem has developed and the afforestation attempt can be considered to have been successful.

At Come-by-Chance which is intermediate in exposure between Chapel Arm and Mobile, trees grew only on microsites where some shelter was afforded by other shrubs and small trees. Ploughing had caused erosion in the furrows and this washed away small trees but provided some protection for others in the hollows.

Growth was poorest at the most exposed site at Chapel Arm. The organic layer was shallow, 10 cm or less, and it was much broken up by ploughing. Some trees were washed away in the furrows. The ploughing also

---

[3]Sitka spruce 64-84%, black spruce 39%, white spruce 37%.

Table 6. Average total height of planted trees over two periods in four plantations.

Species/ Seedling Age	Average Total Height (cm), Each Plantation, Each Measurement							
	Avondale		Come-by-Chance		Chapel Arm		Mobile	
	15	20	8	20	8	20	8	20
Jack pine	328	480	-	-	-	-	-	-
Scots pine	273	412	54	156	46	102	-	-
Black spruce	120	173	38	72	34	57	34	66
White spruce	121	233	-	-	-	-	-	-
Norway spruce	-	-	-	-	-	-	31	54
Sitka spruce	62	72	34	30	25	49	35	53
Eastern larch	412	569	71	328	68	179	-	-

created some microsites where "nutrient sinks" and shelter allowed for the development of healthy foliage. To an extent all species are affected by the wind and exposure but only the spruce has developed the distinctive "krummholz" habit, characteristic of alpine tundra areas (Arno and Hammerly 1984). This has occurred at all plantations except Avondale. Characteristically, all shoots above the snowline are killed by winter desiccation leaving a mat of often healthy foliage which may be a metre or more across but about 15-30 cm tall. The similarity of average heights of the spruces over two measurements reflects this phenomenon (Table 6).

At Mobile the ploughing was quite beneficial and broke up a deep (50 cm) organic layer. Natural vegetation was more abundant on this

site than at all the others and consisted of alders, ericaceous dwarf shrubs, sphagnum moss and sedges. The alders in addition to providing shelter also stimulated growth. Hudson (1985) found a statistically significant difference in height growth of black and Sitka spruce on sites with and without alders. Sitka spruce on the same site was also found to outgrow both black and white spruce by a small margin.[4]

Comparing the species, eastern larch was by far the best, outperforming all others followed by jack and/or Scots pine. Unlike the spruces, larch and pines seem hardy enough to survive above the snowline. Sitka spruce survives well but does not grow on exposed sites. At 20 years from seed, it is not yet a metre tall on any of the four sites. By contrast, measurement of some 20-year-old Sitka spruce of the same provenance planted on a good forested inland site on the Avalon Peninsula reached an average of 4.49 m.[5] The data from the four plantations therefore showed wide variation among species.

Since one of the objectives of the afforestation trials was to determine which species to plant, a second plantation was established at Avondale approximately 2 km from the one already described (Salter and Evans 1976). A total of 3,476 trees of several species was planted in June 1970. No remeasurements were made until the trees were 20 years from seed (Table 7).

---

[4]Ten Sitka spruce provenances 103-144 cm, black spruce 96, white spruce 110 cm. Trees 20 years from seed. Source, Hall, J.P. Unpub. data.

[5]Hall, J.P. Unpub. data.

Table 7. Species planted, survival and growth at Avondale 20 years from seed.

Species planted	Seedlot	Survival	Height (cm)	Diameter b.h. (cm)
Scots pine	49	30	271	4.7
"	51	51	251	4.0
Austrian pine	92	7	261	5.2
"	107	0	-	-
Corsican pine	56, 108*	4	247	4.2
Black spruce	160	27	76	1.2
White spruce**	-	-	265	4.1
Red spruce	26	80	146	2.0
Hondo spruce	52	44	134	1.5
European larch	102	62	435	7.6
"	134	16	410	6.9
Japanese larch	129***	41	557	10.6
"	129	96	557	9.9

*A mixture of the two seedlots was planted and it was not possible to separate the lots when measured.

**An unknown number of local wildlings was planted.

***This seedlot was planted as 4 + 0 seedlings, the other as 3 + 1.

Survival is low for all species except for Japanese larch and red spruce. Larches have by far the best growth; spruces the poorest. Japanese larch, a species shown to have proven the best of the exotics on several sites in Newfoundland, has outgrown all others at Avondale. A marked improvement in survival is attributed to using stock grown three years in the nursery and one year in the transplant bed (3 + 1) over using seedbed grown stock only (4 + 0). A year in transplant beds has also been shown to be advantageous in establishment of white spruce (Hall 1979). The provenance differences in survival of European larch have not occurred in other studies (Hall 1982) so it is assumed that the poor survival of seedlot 134 was due to poor handling of planting stock.

CONCLUSIONS

Afforestation of the heathlands of eastern Newfoundland is a difficult process limited by features such as wet stony soils and high winds which are outwith our ability to control.[6] Within these limits however there are possibilities and opportunities which can be exploited to produce forests of commercial value.

1. Planting sites must be carefully selected. Lower slopes with some established vegetation (alders) should be selected, as shelter is provided by both topography and vegetation. A method of measuring

---

[6]Average annual windspeed measured at St. John's Airport is 24.6 kph which is 3.2 kph higher than that permitting production of commercial forests (cf. Nickerson 1968).

exposure where tatter flags are used to integrate exposure effects has been developed and described in detail by Nickerson (1968). Potential afforestation sites are monitored with these flags and sites where the tatter rate exceeds one square inch (6.45 cm^2) per day is considered to be marginal for forest production.

2. Site modification by ploughing or disc trenching and possibly fertilization (not tested in replanted experiments) can be used to promote drainage and to provide an adequate soil/organic matter mix which improves seedling establishment.

3. Seedlings should be planted deeply to avoid frost upheaval and plantations monitored closely. Heaved seedlings can usually be replanted successfully. Advantage should be taken of favourable microsites within the plantation area.

4. Seedlings should be fairly large, 2 + 2 for spruce and pine and 2 + 1 for larch with vigorous well-developed root systems. In any case at least one year in transplant beds is recommended.

5. Several species seem suitable for planting. The three larch species, eastern larch and Japanese and European larch are easy to establish and outgrow all other species planted on the same sites. Also useful are both jack and Scots pine which are slower growing than larch but tolerate exposure at least as well. Pines on wet sites are often damaged by a root collar weevil (Hylobius spp.) and this limits their use. Spruces survive well but generally do not grow as well as pines or larches. An exception to this is

Sitka spruce which has excellent growth when planted on sheltered sites in association with alder; and Norway spruce which has excellent growth on moist seepage slopes.

6. Spacing should be considered. A narrow range of spacing 1.5 to 2.1 m has been used in plantation establishment and no replicated spacing trials have been established on these heathlands. However, given the potential value in mutual shelter on these sites it would make sense to plant at a closer rather than wider spacing, e.g. 1.5 rather than 2.1 metres.

7. Finally, consideration must be given to the final product. It is not likely however, that afforestation of heathlands will produce timber of sawlog quality; rather firewood will be the eventual product. This product, once out of favor, is now in wide demand and can be produced close to the market.

LITERATURE CITED

Anon. 1974. Forest Inventory Statistics, Newfoundland. Paper prepared by the Government of Newfoundland under shared-cost arrangements with the Government of Canada as part of the Forest Inventory Project for Newfoundland. 71 p.

Anon. 1984. ENFOR Project P-263, Domestic Fuelwood Consumption in Newfoundland by Northland Associates Limited, St. John's, Nfld. 73 p.

Arno, S.F. and R.P. Hammerly. 1984. Timberline - mountain and Arctic forest frontiers. The Mountaineers, Seattle. 304 p.

Case, A.B. 1977. Survival and early growth of trees planted on plowed heathlands of the Avalon Peninsula. Can. Dep. of Fish. and Env., Forest. Ser., Nfld. For. Res. Centre, Unpub. Rep. 17 p.

Evans, C.H. and E.C. Salter. 1969. Record of silvicultural trials and demonstrations. Can. Dep. Fish. and Forest., Forest. Br., For. Res. Lab., St. John's, Nfld. Int. Rep. N-11. 204 p.

Hall, J. Peter. 1979. Early survival and growth of four age classes of white spruce seedlings in western Newfoundland. Can. Dep. Fish. and Env., Forest. Ser., Nfld. For. Res. Centre, Inform. Rep. N-X-165. 10 p.

Hall, J. Peter. 1982. Growth and development of exotic tree species in Newfoundland. Env. Can., Can. Forest. Ser., Inform. Rep. N-X-212. 36 p.

Hudson, A.J. 1985. The influence of Alnus crispa (Ait.) Pursh on the growth, nutrition and survival of Picea mariana (Mill.) B.S.P. and Picea sitchensis (Bong.) Carr. in plantations near Mobile, Newfoundland. BSc (Hons.) Thesis, Memorial University of Newfoundland. 44 p.

Lewis, H.S. 1954. Forest plantations in Newfoundland. Can. Dep. North. Aff. and Nat. Res., Forest. Br., For. Res. Div., St. John's, Nfld. Int. Rep. 16 p.

Meades, W.J. 1983. Heathlands. In Biography and Ecology of the Island of Newfoundland. G.R. South ed. Dr. W. Junk Publishers, The Hague. pp. 267-318.

Mallay, K. and G.R. Milne. 1981. A directory of woodworking industries in Newfoundland. Env. Can., Can. Forest. Ser., Inform. Rep. N-X-216. 84 p.

Milne, G.R. 1984. The Newfoundland sawmill and planing mill industry, 1981/82. Env. Can., Can. Forest. Ser., Inform. Rep. N-X-221. 67 p.

Nickerson, D.E. 1951. Some aspects of the management of unlicensed Crown land near settlements in Newfoundland. For. Chron. 27:200-202.

Nickerson, D.E. 1968. Initial trial of exposure flags on the Avalon Peninsula, Newfoundland. Can. Dep. Forest. and Rur. Dev., Forest Br., For. Res. Lab., St. John's, Nfld. Inform. Rep. N-X-21. 17 p.

Nickerson, D.E., W.C. Wilton and F.F. Tusko. 1964. Test of exotic species for afforestation purposes on the Avalon Peninsula, Newfoundland. Can. Dep. Forest., For. Res. Br., St. John's, Nfld. Rep. 64-N-14. 20 p.

Richardson, J. 1968. Frost upheaval in Avalon Peninsula plantations. Can. Dep. Fish. and Forest., Forest. Br., For. Res. Lab., St. John's, Nfld. Inform. Rep. N-X-23. 13 p.

Rowe, J.S. 1972. Forest Regions of Canada. Can. Dep. of the Environ., Can. For. Ser., Publ. No. 1300. 172 p.

Salter, E.C. and C.H. Evans. 1976. Record of silvicultural trials and demonstrations. Env. Can., Forest. Ser., Nfld. For. Res. Centre, Inform. Rep. N-X-137. 112 p.

Wilton, W.C. 1956. Forest resources of the Avalon Peninsula, Newfoundland. Can. Dept. Nor. Aff. and Nat. Res., Forest. Br., For. Res. Div., Tech. Note No. 50. 24 p.

Wilton, W.C. 1970. Plowing trials for afforestation in Newfoundland. The Forest. Chron. 46:111-115.

Wilton, W.C. and H.S. Lewis. 1956. Forestry problems of the Bonavista Peninsula, Newfoundland. Can. Dep. Nor. Aff. and Nat. Res., Forest. Br., For. Res. Div., Tech. Note No. 26. 31 p.

Wilton, W.C. and C.H. Evans. 1974. Newfoundland forest fire history 1619-1960. Env. Can., Forest. Ser., Nfld. For. Res. Centre. Inform. Rep. N-X-116. 114 p.

Appendix I. Seed origin of species planted on ploughed heathlands, 1966-70.

Species	Seedlot No.	Origin
Jack pine	23	Newcastle, North. Co., New Brunswick
Scots pine	49	Kilen, Norway
Scots pine	51	Vilppula, Kuorevesi, Finland
Scots pine	55	Speymouth Forest, Moragshire, Scotland
Austrian pine	92	Lower Austria
Austrian pine	107	Central Europe
Corsican pine	56	Sherwood Forest, Notts., U.K.
Corsican pine	108	Southern Europe
Black spruce	160	West Branch L., Badger, Nfld.
Black spruce*	-	"Mount Pearl Nursery"
White spruce	24	Guysborough Co., Nova Scotia
Red spruce	26	Northumberland Co., New Brunswick
Englemann spruce	35	Kamloops, British Columbia
Sitka spruce**	29	Terrace-Nass River, British Columbia
Norway spruce	50	Vilppula, Finland
Hondo spruce	52	Tokyo Univ. Forest, Hokkaido, Japan
Eastern larch	27	Guysborough Co., Nova Scotia
European larch	102	Central Europe
European larch	134	Germany (Region VII ?)
Japanese larch	129	Germany (Region VI ?)
White birch	138	Mt. Yatsugatake, Nagano, Honshu, Japan

*Listed in the establishment notes but probably the same as No. 160.

**Three other seedlots of Sitka spruce were planted in the Chapel Arm plantation but only No. 29 was measured because it was replicated in the other plantations.